Earth God’s Great Symphony

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By Dr. Jeff Zweerink <http://www.reasons.org/articles/earth-god%E2%80%99s-great-symphony>

The Los Angeles Philharmonic Orchestra comprises over 100 musicians who play more than twenty distinct instruments. Exquisite talent and diversity of instruments enable the orchestra to produce a stirring variety of musical experiences. Some instruments play the melody, which is the main theme of the music. Other instruments add harmony to complement and fill out the ensemble. The percussion usually keeps the rhythm that enables the whole piece to stay together. Even with all the talent and varied instruments, an orchestra requires a conductor to ensure that all the sections maintain the correct tempo and integrate together to produce a pleasing sound.

When it comes to Earth’s ability to support life, one might suggest it plays like a well-conducted orchestra. Over the last four billion years, its euphony has produced a temperate, life-friendly climate. And this symphony continues today despite dramatic changes in Earth’s history that had the potential to destroy our planet’s capacity to support life. Astronomically speaking, the [Sun was 20–30 percent dimmer four billion years ago](http://www.reasons.org/articles/resolving-faint-sun-paradoxes-part-1) and its luminosity steadily increased to reach today’s value. Geologically, water initially covered Earth’s entire surface, and only after billions of years of plate tectonics did land arise to comprise 30 percent of the surface. Atmospherically, the planet changed twice from dominantly hydrogen/helium/nitrogen to carbon dioxide/nitrogen to nitrogen/oxygen. In concert with all these changes, life’s biological complexity increased in noticeable spurts, often [corresponding to the other dramatic alterations](http://www.reasons.org/articles/oxygen-spikes-jumpstart-life-s-complexity-and-size) to Earth. Three recent discoveries illustrate the remarkable orchestration of events that maintain Earth’s habitability.

**Additional Greenhouse Heating**

The Sun’s decreased luminosity three to four billion years ago posed substantial challenges for Earth’s climate. Less energy hitting the planet’s surface would have led to temperatures low enough for all the water to freeze. And the high albedo (reflectivity) of ice would reflect more of the Sun’s energy into space, further cooling Earth into a permanent snowball. The gases in Earth’s atmosphere generate a greenhouse effect, where the energy from the Sun passes through to heat Earth’s surface but the atmosphere traps the heat before it escapes to space. Water vapor, carbon dioxide, and methane (“the big three”) have provided the dominant greenhouse heating throughout history. However, various strands of scientific evidence show that these three gases, given the Sun’s low luminosity, may not have raised the early Earth’s temperature enough to keep water in a liquid state.

Earth’s early atmosphere likely contained a measurable fraction of hydrogen. By itself, hydrogen adds little to the greenhouse heating of Earth. However, in combination with nitrogen, and both at reasonable abundances, the interactions of hydrogen and nitrogen produce greenhouse heating in a different part of the electromagnetic spectrum than the big three. Hydrogen/nitrogen interactions probably contributed enough heating to raise Earth’s temperature above the [freezing point of water even with the Sun’s luminosity as low as 75 percent of current values](http://www.sciencemag.org/content/339/6115/64).1Fortunately, the hydrogen gas escapes to space so that this potent greenhouse heating subsides as the Sun shines more energy on Earth’s surface.

**The Importance of Clouds**

Although greenhouse gases significantly warm the Earth (removing all greenhouse heating would drop the surface temperature by 33oC, well below water’s freezing point), [clouds also play an important role](http://www.reasons.org/articles/articles/climate-change-cool-clouds). Most studies of Earth’s early climate that assumed a reduced solar output utilized models that could not adequately account for cloud cover or ice. Recent studies of global climate change have produced more accurate models that include cloud and ice effects (although they still have deficiencies).

Scientists applied these climate models to Earth’s condition 2.8 billion years ago, when Earth received 20 percent less energy from the Sun. Assuming modest amounts of greenhouse gases, the models show that including the effects of clouds and ice leads to [a planetary surface dominated by open oceans (although with large polar ice caps](http://online.liebertpub.com/doi/abs/10.1089/ast.2012.0936)).2

On an interesting note, clouds play two different roles in Earth’s climate. Some clouds reflect the Sun’s radiation back into space, thus cooling Earth. Other clouds trap the Sun’s energy inside Earth’s atmosphere, leading to warming. The temperate climate seen throughout the planet’s history indicates that the atmosphere housed the right kind of clouds at the right times as the Sun grew brighter.

**Dynamic Plate Tectonics**

Along with the changes in Earth’s atmosphere, continents formed in geological spurts between [one and three-and-a-half billion years ago](http://www.reasons.org/articles/the-age-s-of-the-continents). In fact, the growth of continents wrought some of the atmospheric changes by exposing rocks that interact with and remove carbon dioxide from the air. Scientists do not completely understand all the important details that drive plate tectonics but they have a general picture.

[Active plate tectonics](http://www.reasons.org/articles/earth-just-barely-large-enough) requires a thin, rigid plate that moves across a more malleable surface underneath (think of a raft on a river). The formation of rigid plates involves the removal of water to stiffen the plates. The malleable surface underneath often requires the addition of water to induce or amplify the melt content of the material. In part, the [unique properties of the mineral content (with some added aluminum)](http://www.reasons.org/articles/extra-extra-read-all-about-it) yield a decrease in water solubility at the boundary between the rigid plates and the material underneath. This decrease was thought to cause both the stiffening of the plates and the melting below. However, recent research indicates a far more complex scenario than previously thought.

If this were the only mechanism at play, earthquake data would show an abrupt transition from rigid to malleable material beneath all the ocean plates. Instead, measurements reveal an [intermittent melt boundary](http://www.sciencemag.org/content/335/6075/1480.abstract).3

Instead of a continuous melt layer, other mechanisms must work in concert to maintain plate tectonic activity four-and-a-half billion years after Earth’s formation. Hot mantle upwellings, small-scale convection, and fluid release during subduction represent some of the other processes that could enhance the regional melting measured from earthquake data.

**Hearing the Music**

Consider the moments before a symphony starts. Each musician tunes his instrument and warms up in a cacophonous array of discordant sounds. When the conductor arrives and calls the orchestra to order, the chaotic sounds coalesce into a purposeful, meaningful musical story. Earth’s story culminates with the arrival of humanity, but it follows an involved and suspenseful narrative where many events and processes, left unguided, could have destroyed Earth. Instead, the data indicates that the planet’s temperature remained within a life-friendly range for the last four billion years.

Greenhouse gases, cloud circulation, and underground melt processes comprise some of the instruments that work together––despite all the dramatic changes––to maintain Earth’s temperate climate. Looking back through time, it is easy to see the work of a master Conductor ensuring each instrument moves the story in the proper time and in the proper way.

Subjects: Geophysical Design

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While many Christians and non-Christians see faith and science as in perpetual conflict, I find they integrate well. They operate by the same principles and are committed to discovering foundational truths. [Read more about Dr. Jeff Zweerink.](http://www.reasons.org/about/who-we-are/jeff-zweerink)



1. Robin Wordsworth and Raymond Pierrehumbert, [“Hydrogen–Nitrogen Greenhouse Warming in Earth’s Early Atmosphere,”](http://www.sciencemag.org/content/339/6115/64) *Science* 339 (January 4, 2013): 64–67.

2. E. T. Wolf and O. B. Toon, [“Hospitable Archean Climates Simulated by a General Circulation Model,”](http://www.ncbi.nlm.nih.gov/pubmed/23808659) *Astrobiology* 13 (July 13, 2013): 656–73.

3. Nicholas Schmerr, [“The Gutenberg Discontinuity: Melt at the Lithosphere-Asthenosphere Boundary,”](http://www.sciencemag.org/content/335/6075/1480.abstract?sid=52046fc8-52fc-400c-86f9-dd2062d6d538) *Science* 335 (March 23, 2012): 1480–83.